# Executive Summary

In May-June, 2002, a multidisciplinary expedition comprised of biologists, chemists, geologists and engineers conducted a field program on the Galápagos Rift between 86ºW and 89.5ºW (Figures 1, 2 and 3). Objectives of the expedition included revisiting the site of one of the first-discovered low-temperature hydrothermal vents at Rose Garden (originally found in 1979) (Figure 4; Table 1), and searching for new low- and high-temperature vents along the largely unexplored western portion of the Galápagos Rift to 89.5ºW. The field work was funded primarily by NOAA's Ocean Exploration Program with additional support from the National Science Foundation and Woods Hole Oceanographic Institution. A synergistic array of deep-ocean vehicles was used for the exploration program (Tables 2 and 3; Plate 1). Alvin and a new digital towed camera were used for making seafloor observations, acquiring digital imagery and collecting samples (Tables 4, 5 and 6). An autonomous vehicle ABE (Autonomous Benthic Explorer) acquired meter-scale bathymetry, near-bottom magnetics and bottom water-properties data to explore for active hydrothermal venting (Figures 5 and 6). Water-column vertical casts and tow-yos with a CTD/rosette were used to explore for plumes emanating from high-temperature vents.

Alvin and ABE were used to explore for the Rose Garden vent field near 86º13.5'W (Figures 5 and 7). Detailed bottom-water temperature maps (Figure 6) and seafloor magnetics data (Figure 8), in conjunction with visual and photographic observations (Figures 9, 10 and 11) from Alvin and the towed camera, confirmed that the Rose Garden vent field and associated animal community no longer exists, and that prolonged high-temperature venting appears to never have occurred in this area. However, a new low-temperature vent field (named Rosebud) was discovered at a depth of 2450 m, and was found to host nascent developing communities on a fresh-looking sheet flow at a location approximately 200 m northwest of the former Rose Garden area (Figure 7).

Following a single dive for vent exploration near 89°W (Figures 12 and 13), a second site of low-temperature hydrothermal activity (named Calyfield; 1670m) was discovered on a portion of the unexplored rift near 89.5W (Figures 14 and 15). Calyfield is the first discovered vent field along this portion of the Galápagos Rift (westernmost along the Rift) and hosts a large vesicomyid (*Calyptogena magnifica*) clam, mussel (*Bathymodiolus thermophilus*), and endemic sponge (n. sp.) community that covers an approximately 60 m x 60 m area (Figure 16 and Plate 15). In addition, extinct high-temperature sulfide chimneys were discovered several hundred meters northeast of Calyfield (Figure 17).

Throughout the cruise, ABE was used during night operations to provide synoptic micro-bathymetry maps, magnetics data and bottom water properties. Early each morning, these data were processed and then provided to the Alvin observers prior to that same day's dive. ABE data were occasionally combined with, or supplanted by, data from the towed camera or the CTD. A total of 9 Alvin dives, 7 ABE dives, 5 camera tows and 6 CTD tows/casts were conducted (Table 3).

The URL for the web site where data from this cruise, and a copy of this cruise report will appear is located at: http://science.whoi.edu/galap_rift.

# 1. Introduction

Discovery of deep-sea hydrothermal vents and associated biological communities on the Galápagos Rift in 1977 (Figure 4) (Corliss *et al.,* 1979) profoundly and permanently changed our view of the deep sea and revolutionized the oceanographic and earth sciences. This discovery, and the subsequent discovery of high-temperature vents at 21°N on the East Pacific Rise (EPR) in 1979 (Spiess *et al.,* 1980), has allowed biologists, chemists and geologists to better understand the complex interactions between hydrothermal, magmatic, and chemical processes at mid-ocean ridges globally (*e.g*., Humphris, 1995; Fornari and Embley, 1995).

### *1.1 Galápagos Vent Biology*

Over the past 16 years, observations during repeat visits to eastern Pacific vent sites indicate that well-established biological vent communities undergo substantial changes in their composition and distribution (Fustec, *et al*., 1987; Hessler and Smithey, 1983; Hessler *et al*., 1985; Hessler, *et al*., 1988; Tunnicliffe *et al*., 1990; Van Dover and Hessler, 1990; Jollivet, 1993). Wholly or partially dead beds of clams (*Calyptogena magnifica*) observed at 21°N EPR between 1982 and 1990 attest to the effect discontinuous vent emission can have on biological communities (Lutz, 1991; Fisher *et al*., 1988). The abundance of *Riftia pachyptila* at 21°N was virtually eliminated by intensive research sampling in 1982, but dramatically increased by 1990 (Lutz, 1991). Vent sites near 13°N EPR experienced periods of marked instability in venting activity between 1982 and 1990 (Jollivet, 1993). Inactive periods of venting were characterized by a sharp decrease in *Riftia* populations, an increase in scavengers, and a persistence of mytilid bivalves (*Bathymodiolus thermophilus*). Reactivation of extinct vent areas was correlated with increased numbers of *Tevnia jerichonana* and *Bythograea thermydron* (Jollivet, 1993).

In 1979 at Galápagos, thriving communities of giant *Riftia* tubeworms dominated the Rose Garden site (Hessler *et al*., 1988; Johnson *et al.,* 1986; 1988). Subsequent visits in 1985, 1988, and 1990 revealed that the number of *Riftia pachyptila* tubeworms declined sharply. Mytilid mussels (*Bathymodiolus thermophilus*) and giant vesicomyid clams (*Calyptogena magnifica*)—competitors for nutrient-laden vent emissions—were displacing the *Riftia* under seemingly constant venting conditions. It appeared that, as hydrothermal flux and hydrogen sulfide concentrations diminish, bivalves gain a competitive edge and gradually replace tubeworms as the dominant vent megafauna. Suspension feeders (*e.g*., serpulid polychaetes, pectinids, siphonophores, and anemones) decrease with diminishing vent activity, while carnivores (*e.g*., crabs, shrimp, and whelks) increase in abundance. Mussels appeared to be the last megafaunal survivors as hydrothermal activity in a vent field ceased. It thus appeared that the spatial readjustment of vent emissions, altered intensity of fluid flux, and the physical effects of tectonic perturbations and anthropogenic disturbance can have dramatic effects on the temporal and spatial variation in vent community structure. These early observations of Galápagos faunal succession proved essential for the development of models of faunal succession employed in more recent time-series studies (*e.g.,* at 9°50'N East Pacific Rise, Shank *et al.,* 1998).

The major biological objectives of the Galápagos 2002 expedition were to assess the temporal and spatial changes that had occurred among and within Galápagos faunal assemblages through a detailed mapping and sampling program. This would be done by correlating variations in faunal and microbial assemblage composition with observed variations in fluid chemistry, pH, and temperature (i.e., nutrition-related properties of the fluids) via extensive biological sampling and *in-situ* and laboratory analysis of fluid chemistry. In addition, the search for additional vent sites was an important objective so that the full spectrum of Galápagos vent biology could be understood and placed within a global vent system context.

### *1.2 Seafloor Geology, Mapping and Petrology at the Galápagos Rift and Hydrothermal Fluid Sampling*

The original mapping studies carried out in the Galápagos Rift provided some of our initial models for volcanic and tectonic processes at intermediate to fast-spreading mid-ocean ridges (MORs) (Table 1) (Allmendinger and Riis, 1979; Ballard *et al.*, 1979; van Andel and Ballard, 1979; Crane and Ballard, 1980). We planned to expand on those original works by producing detailed topographic maps around the vent sites using Alvin's near-bottom sonar systems (Imagenex pencil-beam altimeter), and mapping similar high-resolution bathymetric mapping sonars on ABE, in order to provide the detailed context of the vent areas within the rift valley.

Although the first low-temperature vents found in the Galápagos Rift were not associated with significant hydrothermal precipitates, an extremely wide range of hydrothermal deposits formed at a variety of temperatures has been reported from active and fossilized vent sites in the Galápagos Rift (Table 1) (*e.g.,* Malahoff *et al.,* 1983; Herzig *et al.*, 1988, Embley *et al.,* 1988). They include sulfide deposits, mounds of Fe-smectites and manganese oxyhydroxide, and fields of chimneys composed of amorphous silica (*e.g.,* Cauliflower Garden at 85°53-54'W). In addition, exposures of stockwork zones underlying large Cu-Zn sulfide mounds have also been reported (Embley et al., 1988; Ridley *et al.,* 1994), allowing both hydrothermal deposits and the associated altered volcanic rock to be collected.

We planned to analyze a selected suite of hydrothermal fluid, biological, and mineral deposit samples to be collected on the cruise for the following research objectives:

i) characterize the range and distribution of hydrothermal communities, fluid chemistry, and mineral deposits in the Galápagos Rift in order to correlate the chemistry of the hydrothermal precipitates with the fluid compositions and biological communities based on modeling studies of heat and mass transport reactions. For inactive sites, substrate chemistry and isotopic signatures of selected minerals would determine the likely conditions of precipitation.

ii) investigate the relation between the different types of hydrothermal deposits and the associated microbial community, as part of a continuation of similar studies at vent sites in the Pacific, Atlantic and Indian Oceans.

iii) compare this hydrothermal system with others on the Mid-Atlantic Ridge, East Pacific Rise, and Juan de Fuca Ridge. These comparative studies would permit us to assess possible links among such parameters as spreading rate, magma supply, local geologic/tectonic setting, duration of activity, fluid composition and temperature, mineralogy, and gross structure morphology, and;

iv) provide a current assessment of the low-temperature hydrothermal fluid chemistry and compare this with the in situ chemical measurements and other diffuse flow vent fluids from the EPR and elsewhere.

### *1.3 ABE Mapping and Exploration*

Autonomous Underwater Vehicles (AUVs) represent vanguard technology that will revolutionize seafloor and oceanographic measurements and observations in the decades to come. In the past ~5 years we have witnessed enormous advances in the capabilities and field-readiness of AUV systems, specifically the Autonomous Benthic Explorer (ABE) developed by engineers and scientists at the Woods Hole Oceanographic Institution (Yoerger *et al.,* 1998).

ABE conducts fully autonomous surveys of the seafloor and is especially well-suited to working in the rugged terrain on the MOR crest (Tivey *et al.,* 1997, 1998, Yoerger *et al.,* 1998). ABE maps the seafloor and the water column near the bottom by following programmed track lines precisely at altitudes of 5 to 30 meters above the seafloor, depending on the type of survey conducted. ABE's unusual shape allows it to maintain control over a wide range of speeds.

Recently ABE has been used for several geological and geophysical research programs in the North and South Pacific (Tivey *et al.,* 1997, 1998, Yoerger *et al.,* 1998, Schouten *et al.,* 2002) which have further proved its reliability as a high-resolution seafloor survey vehicle, and pointed to its unique characteristics to collect detailed, near-bottom geological, geophysical and ground-truthing data (see also a recent cruise web site: http://www.whoi.edu/at74). These new perspectives on seafloor geology and geophysics have revolutionized our ability to image the deep ocean and seafloor and have already fostered a paradigm shift in field techniques and measurements that will surely result in new perspectives for earth and oceanographic processes.

During this cruise, ABE was used to map the existing vent fields near 86°W at the Galápagos Rift for near-bottom bathymetry at ~1m resolution (Figure 7) and for near-bottom magnetics (Figure 8). ABE was also equipped with a CTD for use in mapping hydrothermal plumes and for conducting exploratory work at the 89.5°W area where we hoped to locate high-temperature vents (Figure 6). This capability, in addition to the detailed sonar maps produced using the 675 kHz Imagenex sonar on ABE and Alvin, proved to be critically valuable to providing complete coverage of the area around 86° 13’W to explore for Rose Garden, and to provide real-time targets for Alvin to investigate on each dive to this area.

### *1.4 Outreach Activities – Dive and Discover and Ocean Explorer Web Portals*

Our outreach activities were focused through the *Dive and Discover* and NOAA Ocean Explorer web sites, http://www.divediscover.whoi.edu and http://www.oceanexplorer.noaa.gov, which were utilized to target middle-school students (Grades 6-8) and the general public. Our outreach, also through video news conferences with the National Science Foundation and the American Geophysical Union (Spring Meeting), as well as ~daily phone interviews with National Geographic Today and National Public Radio) was structured to provide multiple layers and levels of information rapidly. The backbone of the web sites was a series of educational modules that address basic science concepts central to the research being conducted at sea as well as rapid updates on our exploration of the deep seafloor. References and links are made throughout to provide the viewers with easy access to more detailed and related information. These web sites provided daily updates on our findings and upcoming plans. This includes: still and video images from the seafloor and of shipboard operations, graphical representations of a wide variety of oceanographic data, explanations about the technology being used, and general information about life at sea and the scientists, engineers, and mariners that make oceanographic research possible. In addition, a "Mail Buoy" allowed students to communicate directly by email with scientists at sea.

During the cruise daily postings and other visual information were provided in near real-time to the public, educators and students In addition, as part of the outreach and education effort associated with this expedition, we produced a CD that commemorates the 25th anniversary of discovery of deep sea hydrothermal vents and Galápagos exploration. Access to the 25$^{th}$ anniversary Galápagos CD is via the Dive and Discover web portal, or through ordering information available on the web site.

## 2. Research Objectives - Galápagos Rift 86°W-89.5°W

The overarching objective of the Galápagos 2002 expedition (AT7-13; Tables 2 and 3) was to continue the longest time-series studies at hydrothermal vents and provide an integrated foundation for future studies along the Galápagos Rift between ~86°W and ~89.5°W. Through an interdisciplinary, multi-vehicle approach (Plates 1 and 2), we aimed to understand the temporal and spatial changes in biological communities, fluid and rock geochemistry, sulfide mineralogy and geological features associated with this mid-ocean ridge hydrothermal system.

The major coordinated components of the Alvin and ABE (Tables 2 and 4) program consisted of: 1) large and small-scale mapping and sampling of the distribution and composition of biological assemblages; 2) *in-situ* and laboratory analysis of vent fluid chemistry; 3) geological mapping and sampling around the known vent sites near 86°W; and 4) exploration for additional vent sites (both low-T and high-T) out to 89.5°W, where the Galápagos Rift valley shoals as it approaches the hotspot trace of the Galápagos plume.

The major objectives of the Galápagos Rift 2002 Expedition were to:

1. Assess the temporal and spatial changes that have occurred among and within Galápagos faunal assemblages through a detailed mapping and sampling program.
2. Correlate observed variations in faunal and microbial assemblage composition with observed variations in fluid chemistry, sulfide mineralogy and chemistry, pH, and temperature (i.e., nutrition-related properties of the fluids) via extensive biological sampling and in-situ and laboratory analysis of fluid chemistry and sulfides.
3. Explore the Galápagos Rift west of 86°W for previously undetected high-temperature venting and new vent fields/animal communities using ABE, towed camera systems and CTD tow-yos. Any new discovery would be mapped and sampled using Alvin and ABE.
4. Develop a comprehensive model of vent community succession at the Galápagos Rift sites with which to generate and test future hypothesis, and have such models be used to guide the design of future studies and manipulative experiments.

## 3. Preliminary Cruise Results

### *3.1 86°W (May 25-29)*

During the AT7-13 cruise, a new low-temperature hydrothermal vent field (Rosebud) was discovered at the Galápagos Rift at 86° 13'W (Figure 7; Table 5). The biological importance of this finding is two-fold. First, there was no previous evidence for low-temperature venting or robust faunal communities in the area near the Rose Garden vent field (Figure 4) (initially discovered in 1979; Hessler et al., 1988). We observed 24°C vent fluids (the highest ever recorded for Galápagos vents) supporting nascent communities of vent animals growing from cracks in a recent lava flow (Plates 3 and 4). The lava flow has a different geochemical signature from basalt previously sampled from the area around Rose Garden in 1985 (M. Perfit, pers. commun., 2002). The observational and geochemical data suggest a recent magmatic event resulting in a seafloor eruption of lava, probably within the past few years, has paved over the old Rose Garden vent community (as well as the abundant seafloor markers and Alvin weights previously observed in this area). The second remarkable characteristic of the new Rosebud vents is the nature of the faunal communities. The current distribution, size and type of fauna at Rosebud represent assemblages previously unseen at Pacific vents. Rosebud vents simultaneously host youthful assemblages of juvenile *Riftia*, mussels and clams (millimeters to a few centimeters in length). Previously observed community structures have never witnessed the temporal coexistence of these species at such juvenile stages. Also important is that our *in-situ* measurements of fluid chemistry (K. Ding and W. Seyfried, pers. commun., 2002) reveal that extensive suitable habitat space is available yet currently uncolonized. We expect active colonization of this vent field to continue in existing and open habitats and persist for many years.

The Galápagos Rift is a biologically unique system in that its constituent fauna differs from East Pacific Rise (EPR) fauna by 58%. Several key ecological species (*e.g.*, *Tevnia jerichonana* tubeworm) thought to facilitate and direct the sequential colonization of other fauna (*e.g.*, *Riftia*) (Mullineaux *et al.,* 2000) at EPR vents are notably absent at Rosebud. Thus, the ecological mechanisms (*e.g.*, larval input, species interaction, vent fluid chemistry, etc.) controlling the colonization and development of vent communities at the Galápagos Rift are expected to be markedly different from any previously documented at mid-ocean ridges (*e.g.*, Shank *et al.,* 1998; Van Dover, 2000). Similarly, the absence of long-lived high-temperature black smokers at 86°W places temporal constraints on the chemical composition of vent fluids. While the influence of high-temperature fluid chemistry is considered strong on EPR vent communities (Shank *et al.,* 1998; Fornari *et al.,* 1998), this component appears to be absent at the Galápagos Rift at 86°W where our recently collected near-bottom magnetic data show convincingly that no high-temperature venting has ever occurred here (M. Tivey, pers. comm., 2002). Hence the impact of the lack of high-temperature chemical constituents on the development of faunal assemblages and their habitats on the Galápagos Rift is unknown.

Four Alvin dives to the Rose Garden area revealed:

1) a notable absence of the 14 seafloor markers and ~7 stacks of Alvin dive weights that were observed during the last visit to Rose Garden in 1990;
2) a recent sheet lava flow (Figure 9) with a distinctive difference in geochemistry (the Rosebud flow has greater {0.6 wt. % more} MgO content than N-MORB flows sampled around Rose Garden in 1985 (M. Perfit, pers. comm. 2002);
3) numerous areas of suitable but unoccupied vent habitat adjacent to areas where juvenile (mm- to cm-length) individuals of *Riftia*, mussels, and clams are colonizing the young sheet lava surface;
4) vent fluid temperatures of 24°C and concentrations of reduced chemical species significantly higher than any previously recorded from any Galápagos Rift vents.

Thus, the well-developed faunal communities documented 12 years earlier (Alvin dive # 2224 in 1990) at Rose Garden have apparently been buried by a new lava flow. Approximately 200 meters northwest of Rose Garden, a new site, Rosebud (2470m depth)(Figures 7, 10 and 11; Plate 3), supported vent animal communities that are presently in the early stages of development. The faunal communities are developing in fluids exhibiting the highest temperatures (24°C) and $H_2S$ concentrations (>0.55 mmol per L) yet observed on the Galápagos Rift (Table 5). Extensive sampling of these nascent communities revealed that they contained less than one-third of the species known from Rose Garden when last sampled 12 years ago.

Photomosaics and detailed imaging surveys (facilitated by the deployment of seafloor markers; Table 6; Plate 4) of the Rosebud vent field (Figures 9 and 10), which covers an area of approximately 60m x 50m, revealed that this site consists of 4 major venting areas containing vestimentiferan tubeworms (majority less than 6 cm in length), linear rows of bathymodiolid mussels (average ~1cm in length) growing along cracks in the sheet lava surface, and adjacent carpets of amphianthid anemones (ca. 50 per square meter) (Figure 11; Plates 8-14 and 16). A single assemblage of larger mussels (>10cm) was observed on the northeastern margin of the field. Vesicomyid clams (ca. 10 individuals), all less than 3 cm, were observed along cracks in the central sheet flow.

Based on extensive time-series analysis of biological community structure and hydrothermal venting on the EPR (*e.g.*, Haymon *et al*., 1991, 1993; Lutz *et al*., 1994; Von Damm *et al*., 1994, 1996; Fornari *et al.,* 1999; Shank *et al.,* 1998, 2001), the age of the Rosebud communities is likely to be much less than 2.5 years old. Two unique observations may be made with the data available and based on preliminary shore-based analysis.

1) At Rosebud, there is the presence of unoccupied habitat space that is bathed with $H_2S$-laden fluids and low concentrations of methane.
2) The simultaneous presence of young/actively colonizing tubeworms, clams, and mussels, are inconsistent with any structural or successional pattern previously documented at eastern Pacific vents (Hessler *et al.,* 1988; Lutz *et al.,* 1994; Shank *et al.,* 1998; Mullineaux *et al.,* 2000). At the EPR, mussels are first observed only after tubeworms have become well established. Similarly, clam assemblages do not begin to form at vents until after mussels have become to dominate vent openings (Shank *et al.,* 1998; Mullineaux *et al.,* 2000).

Based on the past decade of vent research, we know that dramatic changes in faunal composition have been brought about by volcanic eruptions and reactivation of sites caused by crustal cracking and subsurface diking without surface volcanic expression (Delaney and Embley, 1993; Embley *et al.,* 1996; Embley *et al.,* 1998; Shank *et al.,* 1998; Fornari *et al.,* 1999; Tsurami and Tunnicliffe 2001). These periods of relative instability have led to a remarkable synchrony in patterns of community succession correlating positively to chemical concentration of post-eruptive vents fluids (Shank *et al.,* 1998; Luther *et al.,* 2001). Our current theories accounting for these structural changes strongly suggest that community succession along the EPR is deterministic, where predictable developmental stages proceed from tevniid tubeworms to riftiid tubeworms to bathymodiolid mussels to vesicomyid clams). ***At Rosebud, the development of all of these successional stages appears to be taking place simultaneously.***

Each of the hydrothermal biological time-series studies conducted to date has emphasized the critical importance of understanding the structure of vent assemblages and their hydrothermal habitats as quickly as possible following an eruptive, cracking, or diking event (Embley *et al.,* 1993, 1998; Holden 1996; Fornari *et al.,* 1999; Lutz *et al.,* 1994; Mullineaux *et al.,* 1996; 2000; Shank *et al.,* 1998; Tsurami & Tunnicliffe 2001). The predominant processes responsible for the formation and development of species assemblages are most discernable during the "active phase" of species colonization that occurs within 2-4 years following an eruption/event (Lutz *et al.,* 1994; Mullineaux 1996; Shank *et al.,* 1998). The historical effects on virtually all marine community dynamics can be effectively erased after several years as communities transfer from modes of assembly to maintenance. The frequency of tectonic and magmatic activity on the ridge crest provides an additional level of complexity if time-series observations are not initiated within an ecologically relevant time scale (identifying that time scale has been a critical goal of the RIDGE2000 Event Response Program) where the relative age of the incipient vents are known.

***3.2 89°W Exploration (May 30)***

Dive 3792 was conducted at a prominently rifted, but shallow portion of the Galápagos Rift near 89°W (Figures 12-13). The objective of the dive was to explore for evidence of hydrothermal venting within the rift graben that is ~500 m wide and 30-40m deep. The dive traversed the graben from south to north, and then doubled back to the graben floor and proceeded west for nearly 2.5 km. Extensive areas of ponded and lava lake terrain were observed in the graben floor, however, no hydrothermal vents or evidence of low-temperature venting or deposits were observed (Plate 7). Numerous samples of basalt were collected and preliminary analyses suggest they are ferro-basalts. Several sessile fauna were also collected and preserved.

***3.3 89.5°W Exploration (May 31-June 3)***

Following a multibeam and initial ABE survey, our second of four dives in this region discovered the western-most known vent field on the Galápagos Rift. Calyfield (Figure 14 and 15) (60m x 60m; 1679m; 89° 37'W) is dominated by extensive vesicomyid clam (*Calyptogena magnifica)* communities. This field is similar in appearance to the Clam Acres site at 21°N on East Pacific Rise. Photomosaics constructed via images acquired from Alvin (Figure 16; Plates 15 and 17) revealed the distribution of large clams (ca. 18-32cm) to predominate in the flow contacts between pillow lavas, along with numerous clumps of bathymodiolid mussels (individuals >10 fold larger than those found at Rosebud), sparse vestimentiferan (*Oasisia*) tubeworms, numerous amphipod swarms, and the presence of large patches of a grey encrusting sponge on the pillow basalts. Photomosaics generated of this field from downlooking images aquired by Alvin, show the sponge coverage to increase in density towards the center of the vent field and its absence outside the vent area. The distribution of this encrusting sponge is limited to the actively venting area, and thus appears endemic only to Calyfield.

In addition, extinct high-temperature sulfide chimneys were discovered several hundred meters northeast of Calyfield (Figures 14, 15, and 17). The change in morphology of the Galápagos Rift crest from a wide rifted graben at 86°W to a more domal and shallow ridge at 89.5°W may be related to the interaction of the spreading axis with the Galápagos plume, and the greater availability of melt and enhanced isothermal structure of the lithosphere near the hotspot.

***3.4 Cruise Data Web Site***

An electronic copy of this report and figure as well as future updates and other data from this cruise can be accessed on-line at: http://science.whoi.edu/galap_rift. In addition, results of the Galápagos Rift 2002 Expedition will being presented at the 2002 Fall American Geophysical Union Meeting, San Fransisco, CA (see Appendix 10 for copies of submitted abstracts).

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